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ABSTRACT

Introduction. Tangential gunshot wounds (TGSW) to the head is the high-velocity bullet that does not penetrate the cranium but passes through the tissue adjoining the cranial cavity, creating a “gutter” wound and indirectly causing cerebral injury. This article presents a reporting case of TGSW to the head, discusses the mechanism underlying this traumatic injury and the possible complications resulting from it, and reviews of literature.

Case description. A thirteen-year-old schoolboy was admitted to the emergency department (ER) of the neurosurgery teaching hospital in Baghdad, Iraq, with a tangential gunshot to the head of an unknown source during civilian protests in Baghdad. In addition to a seizure attack in the ER, his Glasgow coma (GCS) scale was 13 initially. The computed tomography showed multiple bilateral brain contusions, interhemispheric haemorrhage, partially depressed fracture of the frontal bone midline, and a Paramedian to the left with a significantly depressed skull fracture. Then, an urgent decompressive craniectomy was performed. The postoperative course was uneventful, with rapid improvement in GCS of 15 one hour after surgery. On the six-month follow-up, the patient reported no further attacks of seizure.

Conclusion. TGSWs are associated with good GCS and favourable prognosis in most cases unless the patient has been deteriorating or has an associated ICH. Moreover, in our case, the history taking, mechanism of the injury, rapid evolution, and radiological imaging have an essential effect on the outcome.

INTRODUCTION

Gunshot injuries to the head represent a driving cause of 6,000 deaths in the United States annually [17]. The majority of all these injuries are deadly, as two-thirds of them die immediately [10]. Tangential gunshot wounds (TGSW) to the head were first described by Sir Geo H. Makins, a British surgeon involved in the army from 1899-1902 [5,9]. Moreover,

Keywords

tangential gunshot wound,
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In TGSW to the head, the high-velocity bullet does not penetrate the cranium. However, it passes through the tissue adjoining the cranial cavity, creating a "gutter" wound and indirectly causing cerebral injury [5]. The absence of intracranial metallic parts of the bullet gives the possibility of a single entry-exit wound in the form of a continuous abrasion, and the presence of underlying intracranial damage on radiological evaluation without direct penetration by the missile is the most characteristics of TGSWs. Furthermore, TGSWs usually present with multiple degrees of brain contusion with or without skull fractures, which, if present, can sometimes contain in-driven bone parts, with or without evidence of skull fracture in imaging studies [5]. This article presents an illustrative case of TGSW to the head, discusses the mechanism underlying this traumatic injury and its possible complications, and reviews the literature.

CASE SCENARIO

A thirteen-year-old schoolboy was admitted to the emergency department of the neurosurgery teaching hospital in Baghdad, Iraq, with a tangential gunshot to the head of an unknown source during civilian protests in Baghdad. The patient underwent a primary survey and was immediately sent to take a computed tomography (CT) scan. However, he was aware of the time, place, and date, but he and his escort could not remember the way of the injury. On examination, a grazing head wound was recognized alongside a depressed fracture of the right frontal part of the head with no CSF leak. In addition, the patient was fully conscious and aware, obeying commands with a Glasgow coma score (GCS) of 15, and no further findings were noticed on neurological examination.

Along with wound cleaning, the bone fragments were removed, and the patient was kept under observation. After one hour, his condition began to deteriorate, becoming drowsy with a GCS of 13 (eye-opening 4, verbal response 3, and motor response 6). The patient developed multiple attacks of tonic-clonic seizures. Besides, an urgent non-contrast CT scan of the brain revealed multiple bilateral brain contusions and interhemispheric hemorrhage (figure 1. A) and partial depressed fracture of the frontal bone midline, and a Paramedian to the left with a significant depressed skull fracture (figure 1. B). He received prophylactic antiepileptic drugs to

control the attacks of seizures and prepare for urgent decompressive craniectomy to restrain rising intracranial pressure and relieve brain swelling. The underlying dura was intact, and no intraoperative complications were encountered. Postoperatively the patient rapidly improved with a GCS of 15 one hour after surgery. The patient was discharged one week later with no seizures reported during hospitalization. The patient reported no further seizure attacks during the six-month follow-up appointment, and the radiological evaluation did not show any new abnormalities.

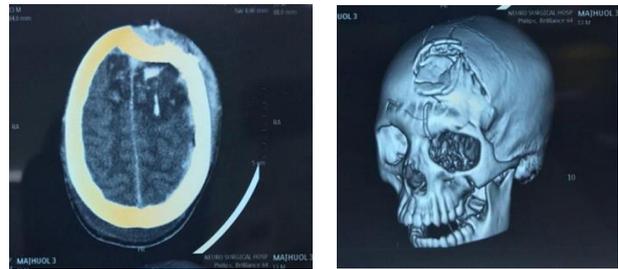


Figure 1. A: non-contrast CT scan shows an axial section of the brain and bone window Showing depressed left frontal skull fracture with underlying multiple bilateral brain contusion and interhemispheric hemorrhage, **B:** 3D reconstruction brain CT scan showing partial depressed fracture of the frontal bone midline and Paramedian to the left with multiple Comminution reveals the presence of significant depressed skull fracture.

DISCUSSION

Gunshot head injuries are the second leading cause of post-traumatic mortality in the United States [12]. They are categorized into perforating, penetrating, and tangential injuries with different mechanisms and prognoses [5]. However, the TGSW of the head represents a moderate-severe blunt injury with a high-velocity missile that does not penetrate the cranial cavity with/without intracranial damages [1,10,17].

The penetrating gunshot wound (PGSW) has no meaningful differences according to age and education from the TGSWs to make them demographically comparable [15]. However, there is little difference between these two groups. PGSW holds high severity compared with TGSW as the PGSW mortality rate is equal to 78% compared with TGSWs, which are approximately 18% [6,12]. Although Hotz GA et al. found in their study that the duration of hospitalization was longer in PGSW than in TGSW, they both have a significant neurological deficit. Furthermore, it is necessary to mention that

if the patient survives the severe stage, which has a higher incidence in the PGSW, they will have the same prognosis [12,14].

Patients with TGSWs commonly present with a good GCS ranged from 13 to 15 in most cases with loss of consciousness which is relatively uncommon [1,6,7,14]. Moreover, in typical cases, the bullet does not breach the skull, and no significant fracture is present. Furthermore, there is a considerable force directed into the brain that has the potential of causing brain pathologies such as intracranial hematoma (ICH) and cerebral contusions which result from disrupted vessels that following the primary damage, site of hematoma related to site TGSWs can be temporal, parietal or posterior fossa [1,4,8,16]. On the other hand, some cases may present with forced depressed fracture and tissue loss according to the distance and the missile velocity. In both of the previous presenting categories, many cases are associated with a neurological deficit that requires rehabilitation facilities [7,8]. In contrast, the presentation can be only a foot drop as Atac *et al.* [3].

It should be noted that the severity and the prognosis of each patient depend on several factors; the type of the used gun, the velocity of the bullet, and the distance from the target, which is demonstrated clearly in I. B. COPLEY *et al.* report. Accordingly, a very high-velocity missile passes through the adjacent tissue and produces brain damage without penetrating it, while low velocity is associated with tissue loss [1,4]. Also, the injured area has a special role anatomically, as ADELOY *et al.* demonstrate the association between the TGSWs in the frontoparietal areas of the brain and the features of "longitudinal sinus syndrome" which is a misnomer since the main underlying cause is a cortical injury in which patients presented with limbs paresis and also a cortical form of sensory impairment was noted without venous any occlusion or thrombosis (8, 14).

Consequently, in the emergency department, the initial management goes with immediate resuscitation and urgent brain CT scan. Prophylactic antibiotics and antiepileptic drugs have a unique role in the management. Besides that, repeated neurological assessment and radiological imaging are very important [4,14]. It is essential to mention that history taking in such injuries is the mechanism; the rapid evolution and management play a crucial

role in the outcome and prognosis of such patients. Moreover, the prognosis is also affected by the presence or absence of depressed fracture and intracranial hemorrhages such as subdural (SDH), epidural hematoma (EDH), traumatic SAH, and ICH [13].

However, Anglin D *et al.* found that approximately 25% of patients with TGSW have ICH. That means there is a case of ICH in every four cases of TGSW. Many authors try to generate criteria to predict the presence of ICH along with TGSW, but obviously, no clear association is stated. However, if the patient present with one or more of the following conditions along with TGSW, he will have an increased risk of developing ICH. The condition is; GCS less than 15 on a presentation or/and if he has a history of a loss of consciousness [4,7,13,14].

According to the mentioned findings, if there is no intracranial pathology, a 12-24h repeated CT scan is a must; as stone *et al.* demonstrate in their study, a late ICH in some cases could be present [1,3,4]. While if there is any acute brain pathology, the time should be less, and the repeated scan should be done in 6h or less if there is any change during the neurological assessment [4]. The line of management and treatment depends on patient status and associated risk. To a much lesser extent, if the patient is alert and oriented about the time and the place, non-operative management with prophylactic antibiotics and antiepileptic are preferable besides wound cleaning and debridement [1,14]. While in more severe cases with a significant hemorrhage that needs an urgent decompression, surgery will be an option [4,16].

Accordingly, In our case, the patient was fully conscious with 15 GCS, then deteriorated to 13 with multiple seizure attacks. The urgent scan show findings necessitate operative management. A craniectomy managed the patient with an elevation of depressed fracture; the superior sagittal sinus (SSS) was intact intraoperatively. In addition, the operation went well without complications, and no neurological deficits were documented in the follow-up period.

In general, the overall prognosis in the TGSWs is good; Özkan Ü *et al.* found in their study that's nearly 60% of patients achieve a good prognosis while the mortality rate less than 19% in other studies, according to the previously mentioned factors and the severity of such cases [1].

Without a doubt, we highlight the importance of the history taking in such injuries, the mechanism of the injury, the immediate evolution and management and its effect on the outcome.

CONCLUSION

TGSWs are associated with good GCS and favorable prognosis in 60% of cases unless the patient has been deteriorating or has an associated ICH.

Moreover, in our report, the history taking, mechanism of the injury, the immediate evolution, and radiological imaging have an important effect on the outcome. Furthermore, the management line and treatment are individualized and dependable on the patient's status and the associated risk factors. All Patients of TGSWs need close observation in a medical facility for at least the first 24 hours post-trauma.

Table 1 Literature review for Tangential gunshot wound to the head (Case Series)

No	Authors	Year of publication	Number of cases	Insinuation	Major finding
1	Adeloye A [8]	1971	6	Nigeria	Fronto-parietal region of the brain is most likely associated with superior sagittal sinus syndrome
2	Copley, I. B. [1]	1991	27	Southern Africa	1- Mortality =18.5% 2- Tangential bullets (especially high velocity) are associated with considerable brain damage, and their effect may delay from a few hours to days 3- Brain damage can occur in the absence of a skull fracture 4- fracture of the inner table may go unnoticed.
3	Anglin D [13]	1998	240	Los Angeles County + University of Southern California Medical Center	1- 25% of all patients With TGSWs to the head had ICHs. 2- There is a higher risk of having ICH if the patient has GCS < 15 on presentation or/and a history of a loss of consciousness.
4	Hotz GA [12]	2000	11	USA	1- penetrating gunshot wound is a more severe and costly injury than a T-GSW to the head 2- TGSW possesses significant deficits, and, if the patient survives past the acute phase of recovery 3- TGSW has less length of stay compared with penetrating gunshot wounds.
5	Özkan Ü [15]	2002	39	Turkey	1- 59% of them have a good prognosis 2- Importance of Periodical followed up with CT scans. 3- In ICU, patients' vital functions should be closely monitored. 4- Immediate follow-up if an infection is suspected

TGSW; Tangential gunshot wound to the head, ICH; Intracerebral hemorrhage, GCS; Glasgow coma scale, CT; Computed tomography, ICU; intensive care unit.

Table 2 Literature review for Tangential gunshot wound to the head (Case Reports)

Case	Type /Age/sex	Presentation	GCS*	Imaging	Management	Outcome
Hadas et al. 1990 [7]	Civilian 27 Y male	Wound in Lt Temporozygomatic region (Lt temporal); 15 minutes later,	15/15 15 minutes later, 8/15	CT scan / Lt temporal Subdural hematoma	Craniotomy with hematoma evacuation	GOS =5

		several spells	vomiting						
Stone et al., 1991 [16]	Civilian 16 Y male	Wound over occipital	RT	10/15 one hour later became less than 8/15		CT scan/Subdural hematoma in the posterior fossa with Rt cerebellar hematoma	Suboccipital craniectomy with hematoma evacuation		GOS =5
Atac K et al. 2004 [3]	Civilian 21 Y male	wound over the scalp with only weakness of dorsiflexion		15/15		MRI/ hyperintense contusion of the Rt SFG with mild subdural hematoma	Conservative Management		GOS =5
Robles 2012 [14]	Military 22 Y male	Rt parietal, posterior linear wound about 12 cm; fracture was observed in the same area		15/15 after 1.5 hours 11/15		CT scan/Intracranial occipital hematoma bone fragment, hematoma causing mass effect	Evacuation of hematoma		GOS =5
Farhat 2012 [14]	19 Y male	Left Temple & near small midline wounds		15/15		Small Left SDH with traumatic SAH (small) minor temporal contusion, 8 hours later brain edema	Conservative Management		GOS =5
The present Case 2022	Civilian 13 Y male	Right frontal area with a depressed fracture		15/15, one hour later 13/15 with tonic-clonic seizure		multiple bilateral brain contusion and interhemispheric	urgent decompressive craniectomy		GOS =5

Glasgow Outcome Score (GOS)

1. Death, 2. Persistent vegetative state, 3. Severe disability, 4. Moderate disability, 5. Low disability

Glasgow Coma Scale (GCS) on initial presentation

ABBREVIATIONS

TGSW; Tangential gunshot wound to the head, PGSW; penetration gunshot wound, ICH; Intracerebral hemorrhage, GCS; Glasgow coma scale, CT; Computed tomography.

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